Standards for Technological and Engineering Literacy

The Role of Technology and Engineering in STEM Education

EXECUTIVE SUMMARY

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ITEEA

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This Executive Summary is a joint project of International Technology and Engineering Educators Association (ITEEA) and its Council on Technology and Engineering Teacher Education (CTETE).

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The Importance of Technology and Engineering

Technology and engineering are pervasive in all aspects of our lives. Every human activity is dependent upon the products, systems, and processes we have created to help us grow food, provide shelter, communicate, work, and recreate. As the world becomes more complex, it is increasingly important for everyone to become technologically and engineering literate. We need to understand technology's impacts on our lives, society, and the environment, as well as how to use and develop technological products, systems, and processes to extend human capabilities.

Educators and members of the public realize that K-12 students need to have fundamental literacies in technology and engineering. In 2014, the National Assessment Governing Board (NAGB), through the National Assessment of Educational Progress (NAEP, also known as the Nation's Report Card), administered the Technology and Engineering Literacy Assessment (NAEP-TEL) to 21,500 Grade 8 students across the United States. This assessment challenged students to apply their technology and engineering knowledge and problem-solving skills by using computerized scenarios based on real-life situations. In May 2016, the Change the Equation organization (CTEq) report identified that U.S. middle school students lacked technology and engineering experience and noted: "Without intentional strategies to expose many more young people to technology and engineering, we are leaving a critical aspect of students' education to chance" (CTEq, 2016, p.1).

Redefining Technology and Engineering

Technology and engineering education programs provide a unique mechanism for achieving these and other goals by delivering an integrated, design-based approach to teaching and learning. However, for more students to be able to take advantage of technology and engineering programs currently provided in many elementary, middle, and high schools, something must change. A greater understanding about the role of technology and engineering courses must be promoted. Historically, technically oriented courses have not been as valued as other school course content. The value and importance of technological and engineering literacy is accepted by a wide group of experts. Despite this consensus, formal technology and engineering courses are not available in all schools. Some countries, states/provinces, and localities have put compulsory technology and engineering education programs in place, but many students receive little

or no exposure to the study of technology and engineering, particularly those in Grades PreK-5. Students are graduating with a minimal understanding of one of the most powerful forces shaping society today.

Technology and engineering are complex and constantly evolving, so teachers should spend less time on discrete facts and more time on the broad dimensions of knowing, thinking, and doing in the context of technology and engineering. The ***knowing*** dimension involves taking in information, organizing it, and understanding factual and conceptual relationships. The ***thinking*** dimension entails making sense of information through questioning, analysis, and decision making. The ***doing*** dimension involves using technology and engineering in applied ways such as designing, making/building, producing, and evaluating. All three of these dimensions—knowing, thinking, and doing—are symbiotic and equally important in the development of technological and engineering literacy.

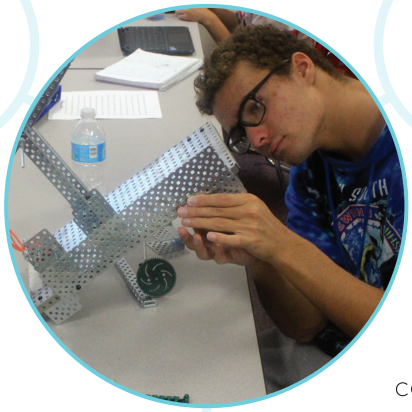
Technology and engineering education is a broad field that encompasses dozens of sub-disciplines. These range from a variety of technological focus areas (e.g., energy technology, transportation technology, biotechnology) to information technology/computer science to the many engineering sub-specialties, among others. Technology and engineering education, as envisioned in ***Standards for Technological and Engineering Literacy (STEL)***, provides an effective launching point for continuing study to prepare individuals to work in these more specialized fields. Technology and engineering education in the PreK-12 environment also provides essential foundational understandings and abilities for all individuals, regardless of their career pathway.

Technology and Engineering is Making and Doing

An important feature of technology and engineering education is its uniquely interdisciplinary delivery method that involves the use of hands-on, design-based strategies to teach and engage students. These authentic experiences often come from co-curricular activities such as service-learning projects or participation in student organizations such as the Technology Student Association (TSA). Co-curricular activities frequently include engaging students in design challenges, technical competitions (e.g., Robotics and TEAMS), and informal learning experiences such as museum visits.

Making and doing have been, and continue to be, foundational components of technology and engineering education. Over time, making and doing within these programs have shifted from producing pre-designed projects focused on developing industrial skills to creating innovative solutions to open-ended engineering design challenges.

The nature of open-ended design challenges allows students to create solutions using multiple approaches.



Open-ended design challenges also provide opportunities for students to optimize solutions based on end users' needs, design constraints, and other criteria. Additionally, open-ended approaches to design allow students to intentionally develop creative solutions and use materials and making techniques in unique ways. This shift to an open-ended design perspective permits technology and engineering educators to foster students' higher-order thinking and design skills while integrating content from other disciplines. It also provides ample opportunities for addressing the overlapping ***STEL*** core standards, practices, and contexts.

Technology and Engineering in STEM

A good deal of attention has been focused on integrated (or integrative) STEM education in the past two decades. Yet, as pointed out in a 2009 National Academies report,

> The STEM acronym is more often used as shorthand for science or mathematics education; even references to science and mathematics tend to be "siloed," that is, treated largely as separate entities. In other words, as STEM education is currently structured and implemented in U.S. classrooms, it does not reflect the natural connections among the four subjects, which are reflected in the real world of research and technology development. (National Academy of Sciences, 2009, p. 12)

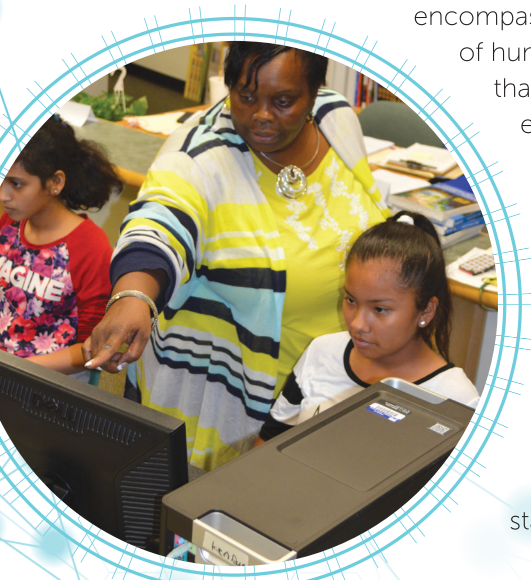
This emphasis on integrated content is reflected in the 2013 ***Next Generation Science Standards***, which incorporates core "dimensions" into all standards, including "science and engineering practices" and "cross-cutting concepts" (NGSS Lead States, 2013). Thus, updated standards for technological literacy require a re-examination of technology and engineering's role within the STEM constellation. Two things are clear: (1) STEM is a unitary force that must be accounted for; and (2) technology and engineering must better establish their role in this disciplinary quartet, including better articulating the core elements of related disciplinary literacies. ***Standards for Technological and Engineering Literacy*** is designed to help educators better understand what technology and engineering education is and how to teach it, while highlighting the interdisciplinarity that is at the heart of technological and engineering activity. All sections of ***STEL*** contain direct examples of how to develop and deliver technology and engineering curriculum and lesson plans with explicit connections to science, mathematics, and the literacies of reading, writing, speaking, and listening.

Focus on Small "e" in engineering

Although the T & E in STEM are often treated synonymously, it is necessary to more closely define the intent of including engineering within the context of ***STEL***. ***STEL*** does not attempt to encompass the full spectrum of engineering content. Technological and engineering literacy, with its emphasis on technological products, design, and technology/society interactions, affords a broader base than would a more exclusive focus on engineering and its content subfields (e.g., mechanical, civil, electrical, and so on). Another way this relationship has been expressed is by referring to the disciplinary study of engineering as a noun (Engineering), and the use of engineering design and application of engineering habits of mind as a verb (engineering). This latter characterization is used in these standards. In this formulation, technology provides the base for the ***STEL*** document while engineering (as a verb) connects the key ideas and selected engineering practices and habits of mind that provide critical linkages within STEM and the broader educational environment.

Standards for Technological and Engineering Literacy (STEL)

Changes in the field of technology and engineering education over the past 20 years necessitate an updated set of standards and benchmarks to drive curriculum, teacher certification, program accreditation, and student learning. A challenge in communicating a clear picture of technological and engineering literacy is that it encompasses a broad area of human activity, one that is constantly evolving. ***Standards for Technological and Engineering Literacy*** distills this broad field into a set of essential knowledge, skills, and abilities (the eight core disciplinary standards and associated benchmarks) that are widely applicable across a range of technology and engineering contexts and that incorporate acknowledged technology and engineering practices. These are described more fully in the five chapters of ***STEL***.

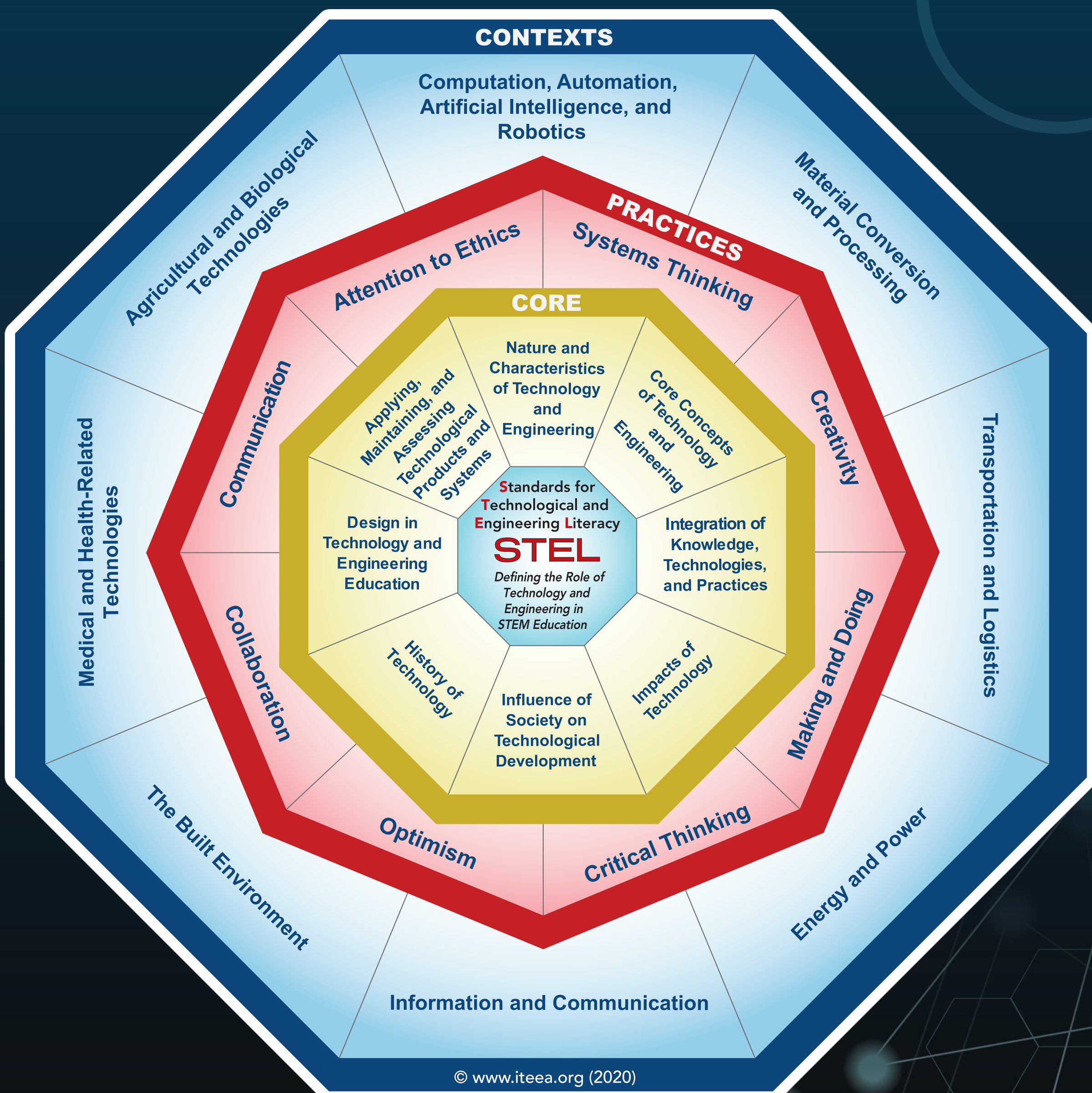


By focusing on essential knowledge, ***STEL*** defines a level of literacy that is expected of all learners across the PreK-12 spectrum, much as we expect all students to achieve a certain level of language literacy, scientific literacy, and mathematical literacy. Technological and engineering literacy is as fundamental to successful participation in the modern world as are these other forms of literacy. ***Standards for Technological and Engineering Literacy*** presents the information that students should know and be able to do in order to achieve a high level of technological and engineering literacy. In other words, the standards prescribe the outcomes for the study of technology and engineering in Grades PreK-12.

STEL Core Disciplinary Standards

Based on the concept of power standards, ***Standards for Technological and Engineering Literacy*** presents eight core disciplinary standards with 142 benchmarks, linked to Grades Pre-Kindergarten through 12. The eight core standards are:

1. Nature and Characteristics of Technology and Engineering
2. Core Concepts of Technology and Engineering
3. Integration of Knowledge, Technologies, and Practices
4. Impacts of Technology
5. Influence of Society on Technological Development
6. History of Technology
7. Design in Technology and Engineering Education
8. Applying, Maintaining, and Assessing Technological Products and Systems



Technology and Engineering Practices

Technology and engineering practices were adapted from the 21st Century Skills (Partnership for 21st Century Learning, 2019) and from research on engineering habits of mind (National Academy of Engineering, 2019). The result is a set of student-centered practices that reflect the attitudes and attributes students will use to successfully apply core disciplinary standards in the different contexts.

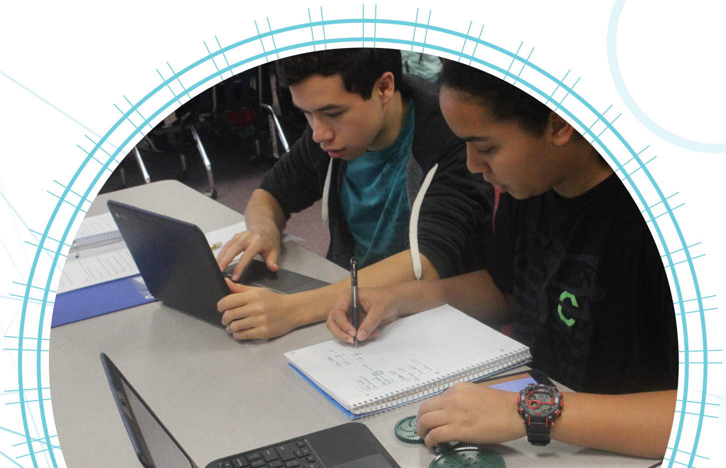
The eight Technology and Engineering practices are:

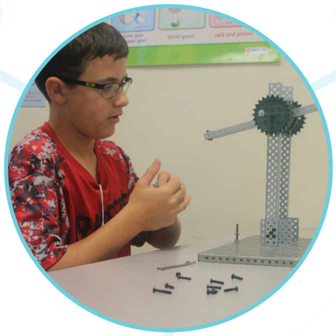
1. Systems Thinking
2. Creativity
3. Making and Doing
4. Critical Thinking
5. Optimism
6. Collaboration
7. Communication
8. Attention to Ethics

Technology and Engineering Contexts

Following the core disciplinary standards and practices are eight contexts common to technology and engineering education. These might also be thought of as content areas, applications, or disciplinary topics but not necessarily as specific courses. The technology and engineering contexts presented in ***STEL*** describe the settings where the core disciplinary standards and benchmarks are best taught or applied. They are:

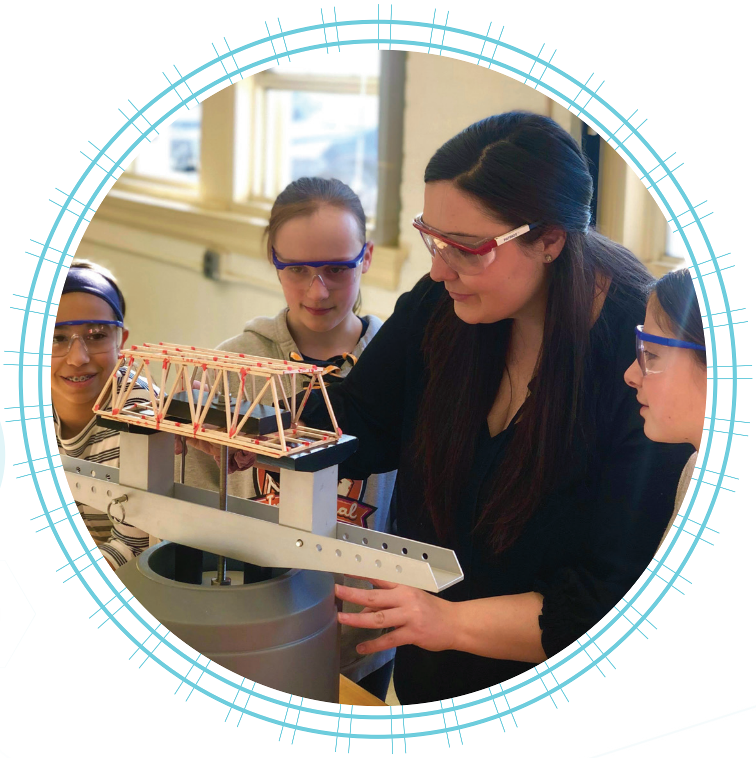
1. Computation, Automation, Artificial Intelligence, and Robotics
2. Material Conversion and Processing
3. Transportation and Logistics
4. Energy and Power
5. Information and Communication
6. The Built Environment
7. Medical and Health-Related Technologies
8. Agricultural and Biological Technologies





Call to Action

There has never been a greater opportunity to bring clarity to the study of technology and engineering and its place in the education of all students. Due to efforts to improve STEM education on a national scale and opportunities for local, state, and federal funding to support STEM programs, now is the time for the field of technology and engineering education to clearly, concisely, and accurately define core disciplinary ***Standards for Technological and Engineering Literacy***. Because the scope of technology reaches far beyond science, mathematics, and engineering, there is a need to provide boundaries by defining these ***core*** disciplinary standards. With a renewed focus on core standards for the study of technology and engineering within the context of a broader STEM literacy, ***STEL*** provides educational policy makers, curriculum developers, teachers, and assessment teams the tools needed to develop and refine curricula, educational policies, and technology and engineering education assessments.



Individuals involved in curriculum development, teaching, or assessment should consider the following recommendations:

- *STEL* is meant to be used in its entirety. All standards should be met for a student to obtain the optimal level of technological and engineering literacy upon graduation from high school.
- The benchmarks specify how students develop across the grade bands toward technological and engineering literacy and what students should know and be able to do in order to meet the standards.
- The core disciplinary standards should be integrated with one another and the technology and engineering practices and contexts rather than presented as separate parts.
- *STEL* should be included in the curriculum at each grade, both in the technology and engineering laboratory-classroom as well as in other subject areas, as appropriate.
- Teachers should be familiar with benchmarks for grades preceding and following the grade level at which they teach.
- *STEL* should be applied in conjunction with other national, state, provincial, and locally developed standards in technological and engineering and related fields of study.
- School systems should begin to move toward a PreK-12 technology and engineering program for all students.

Referenced documents can be found here: *www.iteea.org/STEL-ES-Resources.aspx*

ITEEA's Engineering byDesign™ curriculum model has based all of its publications on the previous *Standards for Technological Literacy* and aligns to complement *Standards for Technological and Engineering Literacy* as well. Support is available from EbD™ to provide Curriculum and Standards Specialists, workshops, and presentations to the educational community. Learn more at ***www.iteea.org/STEMCenter/EbD.aspx***.

WHAT IS ITEEA?

The International Technology and Engineering Educators Association (ITEEA) is the professional organization for technology, innovation, design, and engineering educators. Our mission is to promote technological and engineering literacy for all by supporting the teaching of technology and engineering and promoting the professionalism of those engaged in these pursuits. ITEEA strengthens the profession through leadership, professional development, membership services, publications, and classroom activities. See ***Who is ITEEA*** for a high-level look at ITEEA, its mission, its members, and the importance of technology and engineering education to all students. See also a ***Brief History of ITEEA***.

ITEEA's mission is to advance technological and engineering capabilities for all people and to nurture and promote the professionalism of those engaged in these pursuits. ITEEA seeks to meet the professional needs and interests of members as well as to improve public understanding of technology, innovation, design, and engineering education and its contributions.

ITEEA

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